1994, now U.S. Patent No. 5,525,789; 08/475,376 filed June 7, 1995, now U.S. Patent No. 5,637,852; 08/439,224 filed May 11, 1995, now U.S. Patent No. 5,627,359; and 08/292,237 filed August 17, 1994, now U.S. Patent No. 5,808,285; each commonly owned by Assignee, Metrologic Instruments, Inc., of Blackwood, New Jersey, and ~~is~~ incorporated herein by reference as if fully set forth herein.

On Page 2, amend the second paragraph as follows:

The second class of bar code symbol reader uses a focused light beam, typically a focused laser beam, to sequentially scan the bars and spaces of a bar code symbol to be read. This type of bar code symbol scanner is commonly called a ~~“”"flying spot”~~ “flying spot” scanner as the focused laser beam appears as "a spot of light that flies" across the bar code symbol being read. In general, laser bar code symbol scanners are subclassified further by the type of mechanism used to focus and scan the laser beam across bar code symbols.

On Page 15, amend the second and fifth paragraphs as follows:

Fig. 2D is a partially cut away view of the holographic scanning system of the illustrative embodiment, taken along line 2D-2D of Fig. 2C, showing in greater detail the holographic scanning disc, the arrangement of the beam folding mirror and parabolic light detection mirror associated with an illustrative laser scanning station of the system of the present invention;

~~Fig. 4A is~~ Figs. 4A, 4B and 4C set forth a block functional diagram of holographic laser scanning system of the illustrative embodiment of the present invention, showing the major components of the system and their relation to each other;

On Page 16, amend the third paragraph as follows:

Figs. 6B and 6C are ~~a~~ schematic diagrams illustrating the various beam cross-sections of two laser scanning beams having focal lengths in the far portion of the scanning volume, shown at a number of different points along their respective scanline trajectories as well as between their respective adjacent focal planes, showing astigmatic laser beam overlapping within each interfocal plane region of the three-dimensional laser scanning pattern;

On Page 17, amend the first and fifth paragraphs as follows:

Figs. 8B1 ~~and 8B2~~ through 8B3, collectively, show a table listing the parameters used to represent the geometrical optics model of Figs. 8A and 8A1;

Figs. 10A2 and 10A3 set forth geometrical optics models of the process of a laser beam propagating through a holographic facet on the rotating holographic scanning disc shown in Fig. 10A1, which are used during the disc design process hereof to compute the normalized total out-and-back light diffraction efficiency of each holographic facet to S and P polarized light when no cross-polarizer is used in the holographic laser scanner;

On Page 19, amend the second paragraph as follows:

Figs. 10F1 and 10F2 set forth geometrical optics models of the process of a laser beam propagating through a holographic scanning facet on the rotating scanning disc shown in Fig. 10F, which are used during the disc design process to compute the normalized total out-and-back light diffraction efficiency of each holographic scanning facet in the holographic scanning disc of the present invention, when a cross-polarizer is used in the holographic laser scanner;

On Page 25, amend the last paragraph as follows:

Figs. 19C, ~~19D~~ 19D1, 19D2 and 19E are a set of given parameters, a set of equations, and a resultant set of numbers, respectively, that determine the hologram construction parameters at a second construction-laser wavelength given the desired hologram performance parameters at a first scanner-laser wavelength.

On Page 26, amend the seventh paragraph as follows:

~~Figs. 20D is~~ Figs. 20D and 20D1 set forth a set of equations describing functional relationships among particular parameters in the geometrical optics model of Figs. 20B1 through 20B3;

On Page 27, amend the second paragraph as follows:

Figs. 21C1, 21C2 and 21C3, taken together, provide a flow chart describing a specific procedure for assembling the components of the laser beam production module of the first

illustrative embodiment, and also for configuring the geometrical and optical parameters thereof in accordance with the principles of the present invention; and

On Page 29, amend the second and eighth paragraphs as follows:

Fig. ~~27B1~~ 27B is a set of assumed values for parameters in the geometrical optics model of Fig. 26;

Figs. ~~28C~~ 28C1, 28C2 and 28D set forth a set of given parameters, a set of equations, and a resultant set of numbers, that determine the hologram construction parameters at a second construction-laser wavelength given the desired hologram performance parameters at a first scanner-laser wavelength;

On Page 30, after the second full paragraph, insert the following paragraph:

--Fig. 30B1 is a set of assumed values for certain fixed parameters used to construct the geometrical optics model of Fig. 30B.--

and amend the next paragraph as follows:

~~Fig. 30C is~~ Figs. 30C1 and 30C2 set forth a set of mathematical equations describing relationships among particular parameters of the geometrical optics model of Fig. 30A;

On Page 36, amend the second paragraph as follows:

In the illustrative embodiments, the apparatus of the present invention is realized in the form of an automatic code symbol reading system having a high-speed holographic laser scanning mechanism as well as a scan data processor for decode processing scan data signals produced thereby. However, for the sake of convenience of expression, the term "holographic laser scanner" shall be used ~~in~~ hereinafter to denote the bar code symbol reading system which employs the holographic laser scanning mechanism of the present invention.

On Page 37, amend the first paragraph as follows:

In ~~Fig. 2~~ Figs. 2A through 2E, the holographic scanning system 1 is shown with its compact housing enclosure 4 removed from its base 5 which functions as an optical bench for its various optical and electro-optical components. In the illustrative embodiment, the total height of

the scanner housing is 6.96 inches, with width and length dimensions of 12.0 and 13.7 inches, respectively, to provide a total internal housing volume ("scanner volume") $V_{housing}$ of about 1144 cubic inches with a scanner housing depth of 6.96 inches. As will be described in greater detail below, the total three-dimensional scanning volume produced by this ultra-compact housing is 15043.6 cubic inches with a scanning field depth of 30.0 inches. Importantly, the resolution of the bar code symbol that the scanning pattern of the illustrative embodiment can resolve at any location within the specified three-dimensional laser scanning volume $V_{scanning}$ is on the order of about 0.017 inches minimum element width. In the illustrative embodiment (the figure of merit $V_{scanning}/V_{housing}$ = 13.15. As will become apparent hereinafter, using the design principles and methods of the present invention disclosed herein, the figure of merit $V_{scanning}/V_{housing}$ can be maximized under a various range of conditions.

On Page 40, amend the first paragraph as follows:

As best shown in Fig. 3, the holographic facets on the holographic scanning disc of the present invention are arranged on the surface thereof in a manner which utilizes substantially all of the light collecting surface area provided between the outer radius of the scanning disc, r_{outer}, and the inner radius thereof, r_{inner}. In the illustrative embodiment, sixteen holographic scanning facets are used in conjunction with the three independent laser beam sources, to provide an omni-directional laser scanning pattern consisting of forty-eight(48) laser scanning planes cyclically generated at a rate in excess of 56 times per second. ~~In~~ It is understood, however, this number will vary from embodiment to embodiment of the present invention and thus shall not form a limitation thereof. As will be described in greater detail hereinafter, the geometry of each holographic facet has been designed so that (1) each of the sixteen holographic facets supported thereon has substantially the same (i.e. equal) Lambertian light collecting efficiency, independent of its focal length, and (2) the collective surface area of all of the holographic facets occupies (i.e. uses) all of the available light collecting surface area between the outer radius and inner radius of the scanning disc. The advantage of this aspect of the present invention is that optical-based scan data signals with maximum signal-to-noise (SNR) ratio are produced and collected at the photodetector of each laser scanning station in the system. This, of course, implies higher performance and higher quality scan data signals for signal processing.

On Page 51, amend the first paragraph as follows:

As shown in the system diagram of ~~Fig. 4~~ Figs. 4A through 4C, the holographic laser scanning system of the present invention comprises a number of system components, many of which are realized on boards that have been hereinbefore described. For sake of simplicity, it will be best to describe these system components by describing the components realized on each of the above-described boards, and thereafter describe the interfaces and interaction therebetween.

On Page 54, amend the last paragraph as follows:

As shown in ~~Fig. 4~~ Figs. 4A through 4C, the central processing board 21 comprises a number of components mounted on a small PC board, namely: a programmed microprocessor 42 with a system bus and associated program and data storage memory, for controlling the system operation of the holographic laser scanner and performing other auxiliary functions; first, second, third and forth serial data channels 43, 44, 45 and 46, for receiving serial data input from the programmable decode computers 40A (40B and 40C) and RF receiver/base unit 47; an input/output (I/O) interface circuit 48 for interfacing with and transmitting symbol character data and other information to host computer system 24 (e.g. central computer, cash register, etc.); and a user-interface circuit 49 for providing drive signals to an audio-transducer 50 and LED-based visual indicators 51 used to signal successful symbol reading operations to users and the like. In the illustrative embodiment, each serial data channel is be realized as an RS232 port, although it is understood that other structures may be used to realize the function performed thereby. The programmed control computer 42 also produces motor control signals, and laser control signals during system operation. These control signals are received as input by a power supply circuit 52 realized on the power supply PC board 22, identified hereinabove. Other input signals to the power supply circuit 52 include a 120 Volt, 60 Hz line voltage signal from a standard power distribution circuit. On the basis of the received input signals, the power supply circuit produces as output, (1) laser source enable signals to drive VLDs 53A, 53B and 53C, respectively, and (2) motor enable signals in order to drive the scanning disc motor 11.

On Page 56, amend the first and second paragraphs as follows:

In some holographic scanning applications, where omni-directional scanning cannot be ensured at all regions within a prespecified scanning volume, it may be useful to use scan data

produced either (i) from the same laser scanning plane reproduced many times over a very short time duration while the code symbol is being scanned therethrough, or (ii) from several different scanning planes spatially contiguous within a prespecified portion of the scanning volume. In the first instance, if the bar code symbol is moved ~~though~~ through a partial region of the scanning volume, a number of partial scan data signal fragments associated with the moved bar code symbol can be acquired by a particular scanning plane (e.g. P(i=1,j=3) being cyclically generated over an ultra-short period of time (e.g. 1-3 milliseconds), thereby providing sufficient scan data to read the bar code symbol. In the second instance, if the bar code symbol is within the scanning volume, a number of partial scan data signal fragments associated with the bar code symbol can be acquired by several different scanning planes being simultaneously generated by the three laser scanning stations of the system hereof, thereby providing sufficient scan data to read the bar code symbol, that is, provided such scan data can be identified and collectively gathered at a particular decode processor for symbol decoding operations.

In order to allow the holographic scanner of the present invention to use symbol decoding algorithms that operate upon partial scan data signal fragments, as described above, the 0-th order signal detector and its associated processing circuitry are used to produce a periodic signal X(t), as discussed briefly above. As the periodic signal X(t) is generated by the 0-th order of the incident laser beam passing through the outer radial portion of each holographic facet on the rotating scanning disc, this signal will include a pulse at the occurrence of each holographic facet interface. However, in order to uniquely identify a particular facet for reference purposes, a "gap" of prespecified width d_{gap}, as shown in Fig. 3, is formed between two prespecified facets (i.e. i=2 and 16) at the radial distance through which the incident laser beam passes. Thus, in addition to the periodic inter-facet pulses, the periodic signal X(t) also includes a "synchronizing pulse" produced by the prespecified "gap" which is detectable every $T=2\pi/\omega$ [seconds], where ω is the constant angular velocity of the holographic scanning disc maintained by the scanning disc motor and associated driver control circuitry. Thus, while the function of the 0-th order light detector is to detect the 0-th diffractive order of the incident laser beam, the function of its associated signal processing circuitry is to (1) detect the periodic occurrence of the "synchronizing pulse" in the periodic signal X(t) and (2) simultaneously generate a periodic synchronizing signal S(t) containing only the periodic synchronizing pulse stream. The

construction of such pulse detection and signal generation circuitry is well known within the ordinary skill of those in the art.

On Page 60, amend the last paragraph as follows:

Using the ZEMAX optical program from Focus Software, Inc. of Tucson, Arizona, the spot-diagrams of Figs. 6B and 6C can be generated in order to analyze the astigmatic characteristics of the scanned laser beams comprising the scanning pattern of the present invention. As shown in Figs. 6B and 6C, the spot size (i.e.cross-sectional) dimensions and orientation of a particular scanned laser beam are represented at its focal plane for five different distances along one half of the scanning plane, as well as for two planes above its focal plane and for two planes below its focal plane. In reality, the spacing of these scanning planes from the focal plane are -120mm, -60mm, 60mm, 120mm, respectively. The five different spot-size distances represented along the scanning plane correspond to five different angular rotations of the scanning disc about its axis of rotation. Notably, spot-size diagrams shown in Fig. 6B are for a scanned laser beam having its focal plane located farther out from the scanning window, whereas the spot-size diagrams shown in Fig. 6C are for a scanned laser beam having its focal plane adjacent to the focal plane of Fig. 6B, and closer to the scanning window. The far right side of the spot-size diagram shown in Figs. 6A and 6B represent the middle of the neighboring scanning planes. The middle set of spot-size diagrams represent the cross-sectional diameter and orientation of the laser beam at its focal plane within the scanning volume. The upper set of spot-size diagrams represent the cross-sectional diameter and orientation of the laser beam above its focal plane within the scanning volume. The lower set of spot-size diagrams represent the cross-sectional diameter and orientation of the laser beam below its focal plane within the scanning volume.

On Page 64, amend the first full paragraph as follows:

Having specified the 3-D scanning pattern and platform architecture for a given application, the next step in the scanner design method indicated in Fig. 7 hereof involves using the scanning pattern and volume specifications and scanner housing specifications to design a particular scanning platform comprising a holographic scanning disc of the present invention and an array of beam folding mirrors configured in such a manner so the resultant system produces

the specified scanning pattern. Preferred disk design methods will be described in great detail below with reference to Fig. 8A through 12C. Also, a preferred method of constructing the designed scanning disk will be described thereafter with reference to ~~Figs. 13A through 13E~~ Fig. 13.

On Page 66, amend the last paragraph as follows:

Referring to ~~Fig. 11~~ Figs. 11A through 11C, the major steps involved in practicing the "holographic scanner" design method hereof will now be described in great detail. Notably, this term is used herein to describe the overall process used to design all of the subsystems of the holographic laser scanner including, but not limited to, the holographic scanning disc, the beam folding mirror array, the light collecting and detecting subsystem, the laser beam production modules, as well as the scanner housing within which such subsystems are contained. Thus, the holographic scanner design method hereof comprises a collection of subsystem design methods and processes which interact with each other to provide a composite method. In general, there are numerous embodiments of the holographic scanner design method of the present invention. Factors which influence the design of the scanning disc and light detection subsystem include, for example, the polarization state of the incident laser beam used during scanning operations, as well as the polarization state of the laser light rays collected, focused and detected by the light collecting and detecting subsystem used during light collecting and detecting operations.

On Page 76, amend the second paragraph as follows:

Having created at Block D of Fig. ~~11~~ 11D, a spreadsheet model for the (i,j)th scanline production process, the scanner designer then uses the spreadsheet tool of the HSD workstation to automatically compute the value of parameters in the Scanline Production Model using dependent parameters which are known by either assumption (i.e. initialization) or numerical evaluation. While the order in which particular parameters of the analytical model are numerically evaluated (due to parametric dependency) is generally transparent to the operator of the spreadsheet tool, the scanner designer of the spreadsheet-based Scanline Production Model must know the relational dependency among the various parameters in the analytical structures thereof so that the information nodes and fields underlying the spreadsheet model can be properly structured. Thus for purposes of clarity and completeness, the computational steps

carried out within the spreadsheet-based Scanline Production Model of the present invention during the scanner design process will be described in detail below. It is understood, however, that in practice, many of these steps will be transparent to the scanner designer inasmuch as he or she will need to provide particular inputs into the spreadsheet-based Scanline Production Model, and the Model will automatically produce for display, parameters of relevance to the scanner design process.

On Page 86, amend the last paragraph as follows:

Having calculated the Light Collection Efficiency Factor ζ_i for each scanning facet on the disc under design, the spreadsheet-based Scanline Production Model proceeds to Block I of Fig. 11B where it uses Expression No. 19 in Fig. 8C2 to calculate the Total Light Collection Area of each i-th scanning facet, $Area_i$, on the scanning disk under design. Notably, the first term in Expression No. 19 reflects the fact that all of the available light collecting area between the outer radius and inner radius (i.e., adjacent the disk support hub) is used in apportioning light collecting surface area to each scanning facet on the disk. The second term in Expression No. 19 of Fig. 8C2 reflects the fact that the total light collecting surface area of each facet $Area_i$ is computed by weighing the total light collecting surface area available on the scanning disk by an "equalized" light collecting efficiency factor. As indicated by Expression No. 19 of Fig. 8C2, this "equalized" light collecting efficiency factor is computed by dividing the i-th light collecting efficiency factor by the sum of all light collecting efficiency factors for all of the sixteen facets. Thus, each holographic facet on the scanning disc is capable of collecting substantially the same amount of reflected laser light and directing it onto the parabolic light focusing mirror beneath the disk, independent of the location of the scanned code symbol within the scanning volume of the system. In practical terms, this means that each facet will focus substantially the same amount of light onto a photodetector, independent of whether the scanned code symbol resided at the farthest focal plane or the closest focal plane in the scanning volume.

On Page 87, amend the last paragraph as follows:

At Block J in Fig. 11B, the scanner design uses the spread-sheet based Scanline Production Model to determine, for each facet, the minimal value for the facet inner radius r_i that allows the scanner housing height h to be equal to the desired scanner housing height $h_{desired}$,

specified by customer requirements. This step of the design process involves using the optimized parameters determined above to determine the set of inner radius parameter values, $\{r_i\}$, for all facets on the scanning disk which provides the desired scanner housing height $h_{desired}$, required by the system specifications, below which the beam folding mirrors must be contained while ensuring the production of the prespecified scanning pattern. Before describing the reiterative evaluation procedure used to find the set of minimum inner radius parameter values $\{r_i\}$ which satisfy the necessary conditions to ensure that $h=h_{desired}$, it will be helpful to first describe how the inner radius r_i for each facet can be found in terms of other geometrically related parameters in the system.

On Page 88, amend the last paragraph as follows:

The tilt angle of the beam folding mirror ϕ_j is one of the parameters that can be varied (i.e. assumed) to arrive at a ~~"best'~~ "best" scanner design. It has been found that a large tilt angle (away from the scan beams) results in a shorter housing size, but requires very shallow exit angles for the beams leaving the holographic scanning disk. This makes the scanning disk difficult to fabricate and lowers the overall light diffraction efficiency and thus total light collection efficiency thereof. It also results in unnecessarily high beam speeds. A small tilt angle will result in better exit angles for the beam leaving the holographic disk, but results in a taller scanner housing size and a reduction in the scan lengths of the scan lines for the 16 facet scanning disk of the illustrative embodiment. After several reiterations, an optimum tilt angle ϕ_j for the beam folding mirror was established at 16 degrees from the vertical.

On Page 94, amend the first paragraph as follows:

In Figs. 10J through ~~10L2~~ 10L1, a geometrical optics model (I.e. Lambertian Radiator Model) is presented for calculating the Lambertian light collection efficiency, E_L, of each i-th facet on a scanning disc produced using the disc design procedures of the present invention. The parameters associated with the Lambertian Radiator Model are geometrically defined in Fig. 10K. The set of equations listed in Fig. 10L1 define relationships among certain of the parameters in the model. Notably, the E_L calculation procedure described herein does not include factors related to diffraction efficiencies, holographic disk transmission characteristics for off-Bragg angles, mirror reflectances, window transmission characteristics and bar code label

reflectances. It is understood that all of such parameters must be taken into account to determine the total light collection efficiency of the scanning system. As these miscellaneous factors have been previously discussed hereinabove, modifications to the present procedure to improve its degree of accuracy will readily occur to those skilled in the art.

On Page 103, amend the first full paragraph as follows:

CONVERSION OF SCANNING DISC RECONSTRUCTION PARAMETERS

Typically, there is a great need to mass manufacture the holographic scanning disc in very large numbers. Thus, holographic mastering techniques are ideally used. While any suitable mastering technique can be used, it will be necessary in nearly all instances to holographically record the master facets at a recording wavelength λ_C which is different than its reconstruction wavelength λ_R. The reason for this is generally well known: it is difficult to make holographic facets with high fringe-contrast at the reconstruction wavelength λ_R, which in the illustrative embodiment is about 670 nanometers. Instead, it is easier to record the facets at a spectral wavelength at which high-contrast fringes can be realized and then play back at the wavelength of the VLDs in the scanner.

On Page 105, amend the first and second paragraphs as follows:

As set forth in the table of Fig. ~~28A~~ 28B, the conversion process produces two output parameters, namely: $\theta_{i.2}$, the Angle of Incidence (Reference Beam Angle) θ_R for the second (construction) wavelength λ_C, and $\theta_{d.2}$, the Angle of Diffraction (Object Beam Angle) θ_O for the second (construction) wavelength λ_C, both defined in Fig. ~~13B~~ 13. These two parameters and the aberration correcting optics are used to configure the HOE recording system shown in Fig. ~~13E~~ 13. All other parameters comprising the process model are intermediate parameters inasmuch as they establish relationships between the input and output parameters of the conversion process. In Figs. ~~28B and 28C~~ 28B, 28C1 and 28C2, these intermediate parameters are defined as follows: the incident angle α_1 inside the medium after development processing; the incident angle β_1 inside the medium after processing; d, the surface inter-fringe spacing of the recorded fringes; ϕ, the tilt angle of the Bragg Planes; $\theta_{0.1}$, the Angle relative to the Bragg planes; L, the separation of the Bragg planes, determined by the Bragg condition equation; $\theta_{0.2}$, the Angle relative to the Bragg planes for the second (i.e. construction) wavelength satisfying the Bragg

condition, before fringe development processing; α_2, the Angle of Incidence inside the recording medium for the second wavelength, before fringe developing processing; and β_2, the Angle of Diffraction inside the recording medium for the second wavelength, before fringe developing processing.

Using the input parameters defined above, the output parameters $\theta_{i.2}=\theta_O$ and $\theta_{d.2}=\theta_R$ can be readily computed using Equations No. 10 and 11 set forth in ~~Fig. 28C~~ Figs. 28C1 and 28C2. These two computed parameters, along with the previously determined index modulation Δn_i and the aberration correcting optics can be collectively used to construct the i-th facet of the designed scanning disc using a laser beam having wavelength λ_C and a recording medium having average indices of refraction n_0 and n_2 before and after fringe structure development, respectively. In the illustrative embodiment, the preferred recording medium is dichromated gelatin (DCG) having its maximum light sensitivity in the blue spectral range, and thus the necessary construction wavelength for exposing this recording medium can be produced by an Argon gas laser with a peak spectral output centered at about 488 nanometers. For each designed facet, a set of construction parameters are determined using the above-described method and thereafter used to physically construct a "master" facet at the second (construction) wavelength λ_C. The master facet can then be used to make one or more facet "copies" for mass production of the holographic scanning disk.

On Page 106, amend the last paragraph as follows:

As shown in Fig. 13, each holographic facet is made by producing a reference laser beam from a laser source. By passing the reference laser beam through a beam splitter, an object laser beam is produced in a conventional manner and using anamorphic optics, an object beam is formed having beam characteristics which are specified by parameters f_i and θ_{ri}. Then as shown, both the reference beam and the object beam are directed incident upon a holographic recording medium (e.g. DCG) supported upon a substrate. The angle of incidence for the reference beam is specified by parameter θ_{i2}, whereas the angle of incidence for the object beam is specified by the parameter θ_{d2}, as shown. The geometrical configuration of this recording system is shown in Fig. ~~13E~~ 13 with all of the holographic facet recording parameters illustrated.

On Page 109, amend the first and second paragraphs as follows:

As shown in greater detail in Fig. 15B, each module bench comprises a base portion 65, and an integrally formed grating/mirror support portion 66. As shown in Fig. 15C, the grating/mirror support portion 66 is disposed at an obtuse angle relative to the base portion so that the light diffractive grating 64 will be automatically oriented with respect to the scanning disc at a prespecified angle (determined during the module design method hereof) when the module bench 60 is mounted on scanner bench 5, such alignment is achieved by way of pins 67 on scanner bench 5 receiving alignment holes 68 formed in the underside of module bench 60, as shown in Figs. ~~15, 15A~~ 15 and 15A. The grating / mirror support portion 66 includes a side support surface 69 for supporting the planar mirror 63, and also a top support surface 70 for supporting the light diffractive grating (i.e. HOE plate). Grooves can be formed along these support surfaces in order to securely retain the mirror and the HOE plate.

As shown in Fig. 15B, the base portion also has a recess 71 within which pivot plate 72 is pivotally mounted from pivot point 72, identified in Fig. 15B. As shown in Figs. 15E1 and 15E2, pivot plate 72 has a first portion 72A upon which a cylindrical platform 73 is rotatably mounted, and a second portion 72B upon which VLD and aspheric lens mounting assembly is fixedly mounted. The function of cylindrical platform 73 is to provide a mounting surface for the prism. Any suitable adhesive can be used to secure the prism upon the top surface of platform 73. An adjustment screw can be provided adjacent to the platform so that the cylindrical disk can be secured in position when adjustment of the prism has been completed.

On Page 110, amend the first paragraph as follows:

Subcomponents comprising the VLD and collimating lens mounting assembly are shown in Figs. ~~15E~~ 15E1 through 15H2. As shown in Fig. 15F1 and 15F2, a VLD mounting yoke 75 is provided for pivotally supporting an optics telescopic assembly comprising the VLD block 76 shown in Fig. 15G1 and 15G2, and the lens barrel 77 shown in Fig. 15H1 and 15H2. The function of the VLD block 76 is to securely mount the VLD at one end thereof. The function of lens barrel 77 is to securely retain the aspheric collimating lens 61. A spring is located between the VLD housing and lens barrel for producing a resistive force against the threading action of the lens barrel while adjusting the VLD-to-lens distance parameter. Also, this spring functions to compensate for tolerances in the fit between the lens barrel and VLD block. This feature permits precise adjustment of d while using inexpensive, easy to manufacture components in mass

production applications. The lens barrel and lens together are mounted within the other end of the VLD block, as shown. Threads 77A are provided on the exterior surface of the lens barrel, while matching threads 76A are provided on the interior surface of the bore 76B extending through the VLD block 76. The pin hole 75A in the base of VLD yoke 75 pivots about pivot pin 73C on the pivot plate. This arrangement allows the position of the aspheric collimating lens to be adjusted relative to the fixed position of the VLD, during a configuration procedure to be described in great detail hereinbelow. A spring 81 is inserted into the end of bore 76B which produces a resistive force against the lens barrel as it is threaded into the bore. When the VLD yoke, VLD, lens barrel and aspheric collimating lens are assembled together as a single adjustable subassembly, then the adjustable unit is pivotally supported in a gimbal like manner within the yoke by way of support pins 78A and 78B, shown in Fig. 15G1 which pass through bores 79A and 79B in yoke 75 and screw into thread holes 80A and 80B, respectively, in the VLD Block 76. This arrangement allows the direction of the laser beam from the lens barrel to be adjusted in the up and down direction, relative to the face of the prism and thus the planar mirror. Also, the pivotal mounting of the yoke relative to the base plate, permits the orientation of the yoke, and thus the direction of the laser beam, to be pivotally adjusted relative to the face of the prism during the configuration procedure. Additionally, the pivotal mounting of the pivotal base plate within the recess of the module optical bench allows the direction of the circularized beam emerging from the prism to be adjusted relative to the planar mirror. As will become apparent below, this adjustment mechanism permits the scanner designer to properly configure the components of the VLD so that the above objectives are satisfied in accordance with the principles of the present invention.

On Page 113, amend the first paragraph as follows:

In order to minimize wavelength-dependent dispersion at each facet along the scanning disc of the present invention over the wavelength range of concern (e.g. 600 to 720 nanometers), the diffraction grating in the first optical system described above is positioned at a tilt angle ρ, defined as shown in Fig. 18A. The mathematical expression describing the relationship between the incidence angle θ_{i1}, the diffraction angle θ_{dc1} at the reconstruction wavelength, the wavelength of the incident beam λ_c and the grating spacing d_1 is described by Expression No.1 in Fig. 18C. This equation is simply the grating equation which describes the behavior of fixed

frequency diffraction gratings, such as the compensation plate 63 used in the first optical system. Then using algebraic techniques upon Expression No. 1, an expression for $\theta_{d1}(\lambda)$ can be derived as provided by Expression No. 3 in Fig. 18C. The relationship between the angle of diffraction of the diffraction grating θ_{dc1}, the angle of incidence at the i-th facet θ_{i2} and the tilt angle ρ is described by Expression No. 2 in Fig. 18C. This mathematical expression is derived using a number of well ~~know~~ known trigonometric relations. While each HOE facet on the designed scanning disc has a variable frequency fringe structure in order to realize its focal length f_i, the design procedure models each facet as if it were a fixed frequency grating. This assumption can be made without introducing significant error in the design as the goal of the first optical system is to minimize the beam dispersion through the HOE facets over the range of diffraction angles for which the facets have been previously designed to produce the prespecified scanning pattern. In the illustrative embodiment, the range of diffraction angles is from about 26.6° to about 47.5°, with the average diffraction angle being about 37 degrees. Thus this average diffraction angle 37° will be selected as the diffraction angle used to design the first optical system. This diffraction angle is indicated by θ_{dc2} in the geometrical optics model, and describes the average direction in which the diffracted laser beam is directed towards the beam folding mirrors in the scanning system. Using the above assumption about each HOE facet on the scanning disc allows the facet in the first optical system to be ~~modelled~~ modeled by the well known diffraction equation, expressed in the form of Equation No. 3 set forth in Fig. 18C.

On Page 114, amend the first paragraph as follows:

In order to complete the design of the first optical system, it is necessary to find a set of values for the parameters representing the first optical system which results in minimizing the deviation of the average diffraction angle θ_{d2} over the range of spectral wavelengths that can be expected to be produced from a conventional VLD used to construct the designed laser beam production module. Ideally, the deviation is zero over the wavelength range of interest; however, this is not achievable in practice. Instead, this deviation is minimized over the wavelength range of interest. Finding the set of parameters that will achieve this objective can be achieved by the following procedure.

On Page 116, amend the first full paragraph as follows:

Having designed the diffraction grating employed in the first optical system of the laser beam production module, it is appropriate to briefly address the construction of the same. Typically, there will be a great need to mass manufacture laser beam production modules embodying "wavelength-compensation" diffraction gratings, of the type described above. Thus, holographic mastering techniques are ideally used. While any suitable mastering technique can be used, it will be necessary in nearly all instances to holographically record the master diffraction gratings at a recording wavelength λ_C which is different than its reconstruction wavelength λ_R. ~~This~~ The reason for this is generally well known: it is difficult to make holographic gratings with high fringe-contrast at the reconstruction wavelength λ_R, which in the illustrative embodiment is about 670 nanometers. Instead, it is easier to record the gratings at a spectral wavelength at which high-contrast fringes can be realized and then playback at the wavelength of the VLDs in the scanner. Presently, the preferred recording medium for recording diffraction gratings with high-contrast fringes is Dichromated Gelatin (DCG)) which exhibits its greatest sensitivity near 480 nm. Thus, a blue laser beam is required during recording. In order to record the diffraction grating at its construction wavelength, and then reconstruct the same at another wavelength, it is necessary to translate (i.e. convert) its complete set of construction parameters $\{\theta_{i1},\theta_{dc1}\}$ expressed at the reconstruction wavelength λ_R, into a complete corresponding set of parameters expressed at the specified construction wavelength λ_C. The process illustrated in Fig. 19A through 19E is virtually identical to the process shown in Figs. ~~13A to 13D~~ 28A1 to 28D and can be used to carry out the necessary parameter conversions. Details regarding the process of 19A through 19E can be found by referring to the description of the process of Figs. ~~13A to 13D~~ 28A1 to 28D detailed above. Thereafter, using the converted set of construction parameters, the holographic diffraction gratings can be made using the converted set of construction parameters and the holographic recording system schematically represented in Fig. 19F.

On Page 118, amend the first full paragraph as follows:

In Fig. 20, a geometrical model is provided for a semiconductor VLD which produces a laser beam having astigmatism inherently introduced along the laser beam. In general, it is well known that the laser beam produced from conventional VLDs has two different beam components, namely: a first beam component having a very narrow dimension which is parallel

to the width dimension of the VLD junction (i.e. resonant cavity); and a second beam component having a very wide dimension which is parallel to the height of the VLD junction. For purposes of exposition, the first beam component shall be referred to as the "P external wavefront" of the produced laser beam, whereas the second beam component shall be referred to as the "S external wavefront" of the produced laser beam. These designations S and P refer to conceptual cylindrical wavefronts which spread in a direction perpendicular (S) or parallel (P) to the LVD junction and are not to be confused with the S wave-polarization and the P wave-polarization directions of the incident laser beam at the scanning disk surface, defined hereinabove. As illustrated in Fig. 20, the "S external wavefront" of the produced laser beam is deemed to originate from an "effective S source" located within the volumetric extent of the VLD junction, whereas the "P external wavefront" of the produced laser beam is deemed to ~~original~~ originate from an "effective P source" located within the volumetric extent of the VLD junction. Inasmuch as the "effective P source" is spatially separated from the "effective S source" by some distance δ, referred to as the "astigmatic difference" inherent in each VLD and statistically varying from VLD to VLD, the geometrical model predicts that the "S external wavefront" will diverge at a rate different than the "P external wavefront" along the produced laser beam and therefore the laser beam will exhibit astigmatism in the well understood sense. According to this geometrical model, nearly all of the power of these external wavefront components reside in the Electric Field vector of these electromagnetic wavefronts and the polarization thereof is parallel to the width dimension of the VLD junction, which is commonly referred to as "transverse electric" polarization, or the TE mode of oscillation of the VLD. According to the model, the S point source produces a cylindrical wavefront whose center of curvature is located at the S source, whereas the P point source produces a cylindrical wavefront whose center of curvature is located at the P source. Details concerning the physics of VLDs can be found in "Heterostructure Lasers" Parts A and B by H.C. Casey, Jr. and M.B. Panish, Academic Press 1978. Notwithstanding this fact of VLD physics, it is important to understand that the "effective S source" and the "effective P source" are constructions of the geometrical model which have been developed for the purpose of designing the second optical system of the laser beam production module of the present invention in accordance with the objects of the present invention. While there may be structural correspondence between the "effective S source" and junction geometry and between "effective P source" and junction geometry, there is no need to specify such correspondences herein for

purposes of the present invention. What is important to practicing this aspect of the present invention is to employ this novel geometrical model of the VLD in order to design the second optical system as will be described hereinbelow. The advantage in doing so will become apparent hereinafter.

On Page 129, amend the last paragraph as follows:

It is appropriate at this juncture to describe a specific procedure for assembling the components of the laser beam production module of the first illustrative embodiment, and configuring the geometrical and optical parameters thereof in accordance with the principles of the present invention. This particular procedure is based on the second generalized parameter adjustment method described above using the optical bench shown in Fig. 21A. As indicated in Blocks A, B and C of Fig. 21C1, the few steps of the procedure involve assembling the above-described subassembly upon the pivot plate. Specifically, the VLD 53A (53B, 53C) is first press fitted into one end of the VLD block 76. Then the aspheric collimating lens 61 is mounted in one end of the lens barrel 77. Then the lens barrel is screw-mounted into the VLD block by turning the same 3-4 turns. This step carries out the initial setting of the parameter d. As indicated at Block D, the VLD/lens subassembly is then attached to the VLD yoke 75 by way of pins 78A and 78B pivotally ~~support~~ supporting the VLD and lens subassembly with one degree of rotational movement relative to the VLD yoke. Thereafter, at Block E the VLD yoke 75 is rotatably mounted to pivot plate 72 by way of pivot axis 73C, as shown in Fig.21A. At Block F of Fig. 21C1, the pivot plate and optical subassembly mounted thereon is placed within fixture plates 87 of the parameter adjustment bench.

On Page 134, amend the first full paragraph as follows:

Referring to Figs. 25A through ~~25F~~ 25E and Fig. 26, the design of the first optical system of the laser beam production module of Fig. 23 will be described in detail.

On Page 138, amend the last paragraph as follows:

As shown in Fig. 26, the second optical system designed above is geometrically ~~modelled~~ modeled in a manner similar to that done during the design process. Parameters used to construct the geometric optics model are described in Fig. 27A. Given (assumed) parameters are

set forth in Fig. ~~27B1~~ 27B for the illustrative embodiment. Mathematical expressions describing important relations among certain of the parameters are set forth in Fig. 27C. In Expression No. 4 in Fig. 27C, the angle of diffraction θ_{d2} is expressed as a function of wavelength (in air) λ, tilt angle ρ, grating spacing d_1, grating spacing d_2, and incidence angle θ_{i1}. Assuming parameter values for ρ, d_1, d_2, and θ_{i1}, Expression No. 4 can be reduced to a function dependent solely on wavelength. Then by evaluating this resulting function using different values of wavelength within the bandwidth of the VLD, a plot of diffraction angle θ_{d2} can be plotted, as shown in Figs. 27D and 27D1, a measure of beam dispersion derived. Notably, the laser bandwidth or spread from commercially available VLDs will be about 0.010 microns or less, and thus this will be a sufficient domain for λ. Typically, wavelength variations due to mode hopping are on the order of 0.0003 microns. With such assumed wavelength shifts from the VLDs in the scanning system, the resulting plot from the Beam Dispersion Analyzer indicates that first optical system of the module designed above will maintain the angular deviation (i.e. beam dispersion) of its diffracted laser beam to about 0.0055 degrees.

On Page 139, amend the first full paragraph as follows:

After completing the design of the first optical system of the laser beam production module, the dual-function light diffraction grating used therein can be constructed using holographic recording techniques. Using the grating equation, this fixed spatial-frequency light diffractive grating (HOE) can be uniquely specified by its reconstruction wavelength λ_R and the angle of incidence θ_{i1} and angle of diffraction θ_{i1} required by the design. However, as explained in connection with the design of the scanning disc and the laser beam production module of the first illustrative embodiment, it is easier to construct (i.e. fabricate) the dual-function diffraction grating at a construction wavelength λ_C different than reconstruction wavelength λ_R, selected on the basis of the recording emulsion (e.g. DCG) used to realize the dual-function grating. The parameter conversion process illustrated in Figs. 28A1 through 28D can be used to convert construction parameters for the dual-function grating, into a corresponding set of construction parameters expressed at the construction wavelength λ_C. When calculating the exposure angles at the construction wavelength, the Bragg plane angle within the emulsion must be maintained constant after the construction process. As this process has been described in connection with the construction of each holographic facet on the scanning disc of the present invention, the

details thereof will not be repeated herein to avoid redundancy. After the parameter conversion process of Figs. ~~28A~~ 28A1 through 28D is carried out, the dual-function diffraction grating can be fabricated using the wavelength-converted parameters and the recording system illustrated in Fig. 29.

On Page 141, amend the last paragraph as follows:

In Fig. 30B1, a set of assumed values are presented for various parameters in the model which can remain fixed during the design process, providing various coefficients in the mathematical expressions within the geometrical optics model. In ~~Fig. 30C~~ Figs. 30C1 and 30C2, a set of mathematical expressions are provided which define particular relationships between certain parameters in the geometrical optics model of the second optical system. As clearly illustrated, Expressions No. 1 to 12 lead to the derivation of equations for L_{P2} and L_{S2}, given by Expressions Nos. 11 and 12 in ~~Fig. 30C~~ Figs. 30C1 and 30C2, the image distances of the P source and the S source after being imaged through the aspheric collimating lens and the light diffractive grating. From these functions, the curvature of the S cylindrical wavefront as it immediately emerges from the second surface of the light diffractive grating can be defined as $1/L_{S2}$, whereas the curvature of the P cylindrical wavefront as it immediately emerges from the second surface of the light diffractive grating can be defined as $1/L_{P2}$. Expressed in other words, the radius of curvature of the S cylindrical wavefront as it immediately leaves the second surface of the light diffractive grating is given by L_{S2}, whereas the radius of curvature of the P cylindrical wavefront as it immediately leaves the second surface of the light diffractive grating is given by L_{P2}. Mathcad 3.1 mathematical design program can be used to carry out geometrical optics modelling within the HSD Workstation of the present invention.

On Page 143, amend the last paragraph as follows:

The optical functions performed by each of the components in the second optical system of this embodiment are similar to the functions performed by the components in the second optical system of the first illustrative embodiment. In particular, the S and P sources represented within the VLD produce cylindrical wavefronts emanating from the S and P source locations, respectively. The optical function of the aspheric collimating lens is to pass the S and P wavefronts, while changing the radii of curvature for both of these wavefronts as well as their

apparent centers of curvature. In this embodiment of the second optical system, both the S and P wavefronts are assumed to propagate on axis, and therefore off-axis aberrations will be negligible and thus need not be considered. The optical function of the light diffractive grating in the second optical system is to significantly change the radius of curvature of only one of these cylindrical wavefronts, while minimally changing the radius of curvature of the other cylindrical wavefront. This significant degree of change in the radius of curvature is a strong function of the angles of incidence θ_{Pi1} and θ_{Pi2} measured with respect to the first surface of the light diffractive grating. This functional relationship and the manner in which such dependency is established among the various parameters in the analytical model of this optical system can be readily seen by carefully examining Expressions 1 through 12 set forth in ~~Fig. 30C~~ Figs. 30C1 and 30C2.

On Page 145, amend the last paragraph as follows:

As mentioned in connection with the design of the laser beam production module of the first illustrative embodiment, it simply is not feasible in practice to empirically measure the astigmatic difference δ for each VLD to be used in the construction of a laser beam production module of the second illustrative embodiment. Consequently, it is not feasible to use the mathematical expressions set forth in the table of ~~Fig. 30C~~ Figs. 30C1 and 30C2 to compute the distance d for selected parameter values. Instead, the approach adopted by the design method of the second illustrative embodiment is to exploit the structure of the geometrical module described above and provide a novel procedure and bench for adjusting (i.e. configuring) the parameters of the second optical system to eliminate astigmatism. For clarity of exposition, the parameter adjustment bench will be described first, and thereafter, a generalized version of the parameter adjustment procedure with reference to the process diagram of Fig. 31B. Finally, a particular illustrative embodiment of the procedure will be described with reference to the parameter adjustment bench of ~~Fig. 31A~~ Figs. 31A1 and 31A2 and process diagram of Fig. 31C.

On Page 146, amend the first and second paragraphs as follows:

In ~~Fig. 31A~~ Figs. 31A1 and 31A2, a parameter adjustment system 100 of the present invention is shown for use with the above-described laser beam production module. The function of this bench is to allow the parameters grating tilt angle $\theta_{grating\text{-}tilt}$ and distance d to be

adjusted during the assembly/alignment procedure so that an astigmatism-free laser beam with a desired aspect-ratio is produced. As illustrated in ~~Fig. 31A~~ Figs. 31A1 and 31A2, the parameter adjustment system comprises an optical bench 101 upon which a pivot plate mounting fixture 102 is stationarily mounted. The function of the pivot plate mounting fixture is to mount during the parameter alignment procedure, an optical subassembly comprising module bench 60' and pivot plate 72' with the VLD, barrel, lens mount, and VLD yoke assembled thereon. The pivot plate mounting fixture provides a pivot plate mounting recess designed to securely receive the module bench 60' and its associated optical subassembly.

As shown in ~~Fig. 31A~~ Figs. 31A1 and 31A2, the parameter adjustment system comprises beam scanning device 88 mounted on the optical bench along a first optical axis which, when the light diffractive grating 72' is mounted on grating platform 70, passes through the center of the second surface of the light diffractive grating 72' along an optical axis 103 passing through a scanning disc emulation hologram (H2) 104, a test lens (having length f_{test}) 105, and x-y beam scanner 88, as shown in Fig. 31A2. This adjustment mechanism allows the laser beam to be prealigned relative to the second surface of the light diffractive grating, without the light diffractive grating being mounted during the alignment step. The reason that scanning-disc emulation hologram 104 is required is because the dual-function diffraction grating, by itself, introduces dispersion which would affect the measurements without the use of a fixed frequency grating 104 which corresponds to an "average" holographic facet, with no focal power (e.g. $\theta_i = -43^o$, $\theta_d = 37^o$). Notably, hologram 104 is tilted at angle ρ with respect to the dual-function grating to give zero beam dispersion. If the incidence angle θ (i.e. $\theta_{grating\text{-}tilt}$) is changed during the design of the first optical system, then ρ preferably should be changed in order to improve the reduction of beam dispersion.

On Page 147, amend the first paragraph as follows:

As shown in ~~Fig. 31A~~ Figs. 31A1 and 31A2, the parameter alignment bench also comprises a beam detector (e.g. quadrant-type photodetector) 91. The beam detector 91 is mounted on the optical bench along a second optical axis 106 which, when the light diffractive grating is mounted on grating platform 70 of module bench 60', passes through the center of the first surface of the light diffractive grating 72'. As will be described below, these test

instruments are used to adjust the geometrical and optical parameters of the laser beam production module during the assembly and configuration of the laser beam production module.

On Page 149, amend the second and third paragraphs as follows:

As indicated at Blocks A, B, C and D of Fig. 31C1, the first stage of the particular procedure involves assembling the above-described subassembly upon the pivot plate. Specifically, at Block A, the VLD is first press-fitted into one end of the VLD block 76. At Block B the aspheric collimating lens 61 is mounted in one end of the lens barrel 77. At Block C, the lens barrel is then screw mounted into the VLD block by turning the same 3-4 turns or so to set the distance parameter d to some initial value. At Block D, the VLD/lens subassembly is then attached to the VLD yoke 75 by way of pins 78A and 78B to pivotally support the VLD and lens subassembly with one degree of rotational movement relative to the VLD yoke. Thereafter, at Block E of Fig. ~~31C~~ 31C1, the VLD yoke is rotatably mounted to pivot plate 72' shown in Fig. 23A. At Block F, the pivot plate and optical subassembly mounted thereon is then mounted on module bench 60'. At Block G, module bench 60' with its subassembly shown in Fig. 23A, is then placed within the recess of the mounting fixture 102 of the parameter adjustment bench of Figs. ~~31A~~ 31A1 and 31A2. At this stage of the assembly/adjustment procedure, indicated at Block H, electrical power is applied to the VLD so that it produces laser beam output.

The next stage of the procedure uses the beam photodetector 91 of the parameter adjustment system to align the produced laser beam with the first optical axis of the light diffraction grating. Without the dual-function light diffractive grating mounted to include bench 60' and with the parameter adjustment bench arranged as shown in Fig. 31A1, the first step of this stage, indicated at Block I of Fig. ~~31C'~~ 31C1, involves tilting the VLD/lens subassembly within the yoke so that the laser beam is directed along target axis 106 (i.e. to the first optical axis of the light diffractive grating) and falls upon the target (i.e. quadrant-type photodetector 91). At Block J at Fig. 31C2, the VLD yoke assembly is then rotated until the laser beam passes through the cross-hair of the target at the beam photodetector 91. Notably, the target position is selected so that when the grating and mirror are installed the laser beam strikes the mirror at a position which reflects the beam on Bragg through the dual function grating, as well as on an optical axis which is coplanar with the axis of rotation of the holographic scanning disc. When so configured, the VLD and lens subassembly and yoke assembly are both locked in the position.

On Page 153, amend the last paragraph as follows:

As indicted at Block A in Fig. 33A, the first step of the design method involves light diffraction efficiency analysis (i.e. Bragg sensitivity analysis) for each holographic facet in the previously designed scanning disc. The goal of this analysis is to determine, in the outgoing direction of the scanning disc, the angle of incidence relative to the Bragg angle of the facet (i.e. off Bragg), at which the light diffraction efficiency of the facets drops below a predetermined minimal threshold. Alternatively stated, the goal is to determine the angular range of incidence angles (e.g. from θ_A to θ_B) outside of which the diffraction efficiency of the holographic facet drops below the predetermined minimal threshold. This angular range is schematically illustrated in the geometrical model Fig. 34. As will be described below, this information is theoretically derived from an analysis of the diffraction efficiency of the facets with respect to particular polarization states of the light focused by the parabolic mirror. The mathematical expressions used to analyze such light diffraction efficiency as a function of incidence angle θ_i will differ for the different illustrative embodiments of the scanning disc hereof. In general, three types of holographic scanning disc may be used in any particular scanner design, namely: a scanning disc designed for use without cross-polarizers before the photodetectors; a scanning disc for use with P polarizers before the photodetectors; and a scanning disc for use with S polarizer before the scanning disc, as described above. Thus, Bragg sensitivity analysis for each of these three cases will be described below. In each case, a precise 3-D geometrical model of the holographic laser scanner under design is created, using the parameter values for the various subcomponents thereof determined in prior stages of the scanner design process hereof. Preferably, the 3-D geometrical model produced at this stage should not ~~reflect~~ represent the parabolic light focusing mirrors 14A, 14B, 14C, nor the photodetectors ~~15A;~~ 15A, 15B, 15C, as the precise geometry and relative position of the parabolic mirrors have not been specified at this stage of the design process, nor have the precise locations of the photodetectors been specified. The partial nature of the geometrical model is illustrated in Fig. 34. As will become apparent hereinafter, several critical design stages, involving light diffraction efficiency and ray tracing analysis, must first be performed before such specifications can be accurately obtained in accordance with the principles of the present invention.

On Page 155, amend the last paragraph as follows:

In Figs. 35B1 and 35B2, a Bragg Light Diffraction Sensitivity Model is provided for the scanning disc designed for use without cross-polarizers before the photodetectors, shown in Fig. 10A1. This model contemplates that light of both S and P polarization states is reflected from a scanned code symbol, collected by the holographic facet, focused by the parabolic mirror and eventually transmitted through the holographic facet onto the photodetector for detection. Consequently, Expression No. 14 in Fig. 35C2 provides an expression for the "average" diffraction efficiency for light of S and P polarization states transmitted through each particular facet on the scanning disc, as a function of the angular deviation from the Bragg angle δ_e. The constituent S and P diffraction efficiencies described by Expressions 12 and 13 of Fig. 35C2, respectively, are formulated using the assumed parameter values listed in the table of Fig. 35B1. The mathematical expressions set forth in Expressions No. 1 through 11 in Fig. 35C1 are derived by application of Snell's Law to the geometrical optics model of Figs. ~~35B1 and 35B2~~ 35A1 and 35A2, and principles of the Coupled Wave Theory in volume-type holographic light diffraction gratings, described in great detail in Herwig Kogelnik's paper, supra. Notably, while the "obliquity factors" C_S and C_R defined in Equations 6 and 7 are expressed in terms of the internal incidence angle α and the fringe slant angle ϕ, these parameters can be expressed in terms of θi and θd, as discussed in Kogelnik's paper.

On Page 157, amend the last paragraph as follows:

Referring to Figs. 37A through 37C2, and the geometrical optics model of the scanning disc shown in Figs. 28A1 and 28A2, a Bragg Light Diffraction Sensitivity Model will be described for analyzing the scanning disc designed with an S polarizer placed before the photodetectors, as shown in Fig. 36 i.e., when using the laser beam production module of the second illustrative embodiment. This model contemplates that light of P polarization state is used to scan a code symbol, and light of S polarization state is reflected from a scanned code symbol, collected by the holographic facet, focused by the parabolic mirror and eventually transmitted through the holographic facet onto the photodetector for detection. The S polarizer allows light rays of S polarization to pass onto the photodetector, whereas light rays of P polarization state are filtered out by the polarizer. Consequently, Expression No. 12 in Fig. 37B provides a general expression for the diffraction efficiency of each particular facet on the

scanning disc to light of S polarization state transmitted therethrough. Notably, this characteristic of each facet is expressed as a function of the angular deviation from the Bragg angle δ_e and has been formulated using the assumed parameter values listed in the table of Fig. 37A1. The mathematical expressions set forth in Expressions No. 1 through 11 are derived by application of Snell's Law to the geometrical optics model of the volume-type holographic facets on the scanning disc, as shown in Figs. 35B1 and 35B2. The "obliquity factors" C_S and C_R defined in Expressions No. 6 and 7 of Fig. 37B are derived using the well known principles of the Coupled Wave Theory in volume-type holographic gratings. The functions plotted in Figs. 37C1 and 37C2 show the "normalized" light diffraction efficiency for the holographic facets No. 1 and 16 to S polarized light, expressed as a function of the angular deviation from the Bragg angle, δ_e. Expression No. 12 in Fig. 37B is used to produce such graphical plots. For δ_e=0, which is the case where the angle of incidence is equal to the Bragg angle of the holographic facet, the theoretical light diffraction efficiency of each facet to S polarized light is maximum (i.e. $E_{norm.}$=1) as one would expect. For angles of incidence away from the Bragg angle of the facet, the light diffraction efficiency generally decreases, with some oscillatory behavior. By evaluating and plotting the "normalized" light diffraction efficiency for each holographic facet, the subsystem designer can identify, for each holographic facet, at which angle off Bragg δ_e the normalized light diffraction efficiency is below a minimal threshold (e.g. 0.09). By analyzing such plots, the designer can then determine at which angles focused light rays from the parabolic mirror must be transmitted through the holographic facets with minimal diffraction, and thus maximum power transfer for detection.

On Page 158, amend the last paragraph as follows:

Referring to Figs. 38A through 38C2 and the geometrical optics model of the scanning disc shown in Figs. 28A1 and 28A2, a Bragg Light Diffraction Sensitivity Model is provided for the scanning disc designed for use with a P state polarizer placed before the photodetectors, as shown in Fig. 36 i.e., when using the laser beam production module of the first illustrative embodiment hereof. This model contemplates that light of S polarization state is used to scan a code symbol, and light of P polarization state is reflected from a scanned code symbol, collected by the holographic facet, focused by the parabolic mirror and eventually transmitted through the holographic facet onto the photodetector for detection. The P polarizer allows light rays of P

polarization state to pass onto the photodetector, whereas light rays of S polarization state are filtered out by the polarizer. Consequently, Expression No. 12 in Fig. ~~38B~~ 38B2 provides a general expression for the diffraction efficiency of each particular facet on the scanning disc to light of P polarization state transmitted therethrough. Notably, this characteristic of each facet is expressed as a function of the angular deviation from the Bragg angle δ_e and has been formulated using the assumed parameter values listed in the table of Fig. 38A1. The mathematical expressions set forth in Expression Nos. 1 through 11 of Fig. ~~38B~~ 38B1 are derived by application of Snell's Law to the geometrical optics model of the volume-type holographic facets on the scanning disc, as shown in Figs. 35A1 and 35A2. The "obliquity factors" C_S and C_R defined in Expressions 6 and 7 of Fig. ~~38B~~ 38B1 are derived using the well known principles of the Coupled Wave Theory in volume-type holographic gratings. The functions plotted in Figs. 38C1 through 38C2 show the "normalized" light diffraction efficiency for holographic facet Nos. 1 and 16 to P polarized light, expressed as a function of the angular deviation from the Bragg angle, δ_e. Expression No. 12 is used to produce such a family of graphical plots. For $\delta_e=0$, which is the case where the angle of incidence is equal to the Bragg angle of the holographic facet, the theoretical light diffraction efficiency of each facet to P polarized light is maximum (i.e. $E_{norm.}=1$) as one would expect. For angles of incidence away from the Bragg angle of the facet, the light diffraction efficiency generally decreases, with some oscillatory behavior. By evaluating and plotting the "normalized" light diffraction efficiency for each holographic facet, the subsystem designer can identify, for each holographic facet, at which angle off Bragg δ_e the normalized light diffraction efficiency is below a minimal threshold (e.g. 0.09). By analyzing such plots, the designer can then determine at which angles focused light rays from the parabolic mirror must be transmitted through the holographic facets with minimal diffraction, and thus maximum power transfer for detection.

On Page 165, amend the first paragraph as follows:

The light detection subsystem of the embodiment shown in Fig. 42 comprises photodetector 15A and a system of light collection and focusing optics 110 which avoids folding light rays collected and focused beneath the scanning disc. The light collecting and focusing optics comprise a planar light collecting mirror 111 and a condenser-type focusing lens 112. As shown, the light collecting mirror 111 is disposed beneath the outer portion of the scanning disc,

for receiving parallel light rays falling incident upon and collected by the holographic facet at its Bragg angle. The parallel light rays collected by the planar mirror are directed substantially parallel to the plane of the scanning disc, and are focused by focusing lens 112 to its focal point at which the photodetector 15A is located. One disadvantage of using this light detection subsystem design is that it requires a greater volume of space beneath the scanning disc to accommodate mirror 111, and focusing lens 112 which will typically require a relatively short focal length, at which the photodetector is placed. From a practical point of view, this can often require the placement of the scanning disc motor above, rather than below, the scanning disc, as shown in Fig. ~~42I~~ 42.